

Microbial Assay Technologies for Space (MATs)

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Overview: Microbes are intimately and intrinsically associated with humans, and are necessary for the regenerative cycling of materials (including oxygen, carbon dioxide, nitrogen and other nutrients) in enclosed systems (space), just as they are on the Earth. It is therefore essential to NASA's manned space exploration goals to achieve an advanced capability to understand, manage, and manipulate microbial ecosystems. In nature, microorganisms rarely exist in isolation, but rather live, interact, metabolize, and evolve in highly complex mixed communities in which the various microbes are highly dependent on one another. The metabolic capabilities of a given microorganism in a natural ecosystems, therefore, is determined by a poorly-understood combination of the "core capabilities" of that organism, and the environment in which it finds itself (including the presence or absence of other microorganisms). Traditional microbiology (in which microorganisms are studied in pure single organism monocultures) does not provide for an understanding of the ways in which mixed population compositions and physical spatial distributions evolve and stabilize in response to environmental pressures nor how these composition and distribution characteristics affect net community microbial metabolism. In order to facilitate long-term space exploration it will be of fundamental importance to address these issues.

Key Targets of Mixed Microbial Ecosystem Research for Space Exploration:

- 1) Develop the hardware and core capability to produce and manipulate microbial communities as defined "test systems," for eventual space-based research with integration of microscale technologies for tracking microbial population, process and end-product changes in these test systems as a function of experimental manipulations.
- 2) Leverage this integrated hardware, technical and biological capability to conduct baseline ground-based research targeted to expanding our fundamental knowledge of the principles governing microbial ecosystem complexity, function, physical structure and response to environmental perturbations.
- 3) Utilize these ground-based results to launch defined mixed microbial ecosystems into space environments in order to assess how microbial ecosystems alter organization,

physical structure, gene-regulated activity and elemental cycling function in response to space exposure.

Approach to addressing targets: We have developed the initial ground-based MATS system to provide an experimental capability to study microbial metabolism in complex (both natural and artificially created) microbial communities. Future emphasis should leverage off of the core capability previously developed and continue the development of associated gene-array, image and micro-sensing technologies in order to derive optimum methodologies for rapid determination of changes in complex microbial ecosystems in response to environmental changes. The MATS platform can be used with a wide array of natural and laboratory generated microbial ecosystems. It allows for the exploration of minimal biological diversity / complexity required for self-sustained, long-term maintenance of living microbial ecosystems. This approach is designed to facilitate basic and applied uses examining the role of environmental perturbations (irradiance, temperature, nutrient level, biohazard exposure) on ecosystem survival, function and environmental impact. The self-contained MATS system allows for a heightened degree of researcher control of specific environmental variables, yet is far smaller, with greater sensing capability, than comparable “mesocosm” study facilities. These design features are necessary in order to address the fundamental research and technical requirements to design an optimum system for exploration of how life-supporting microbial ecosystems may alter characteristics and functions in space.